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A METHOD FOR THE MANUFACTURE OF OPTICAL FIBER PREFORM

Katsuyuki Imoto and
Toshio Katsuyama

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A METHOD FOR THE MANUFACTURE OF OPTICAL FIBER PREFORM

[Kofaibabozainoseizohoho]

Inventors:	Katsuyuki Imoto and Toshio Katsuyama
Applicants:	Hitach Seisakusho Co., Ltd. and Hitachi Densen Co., Ltd.

[There are no amendments to this patent.]

Claim

A method for the manufacture of an optical fiber preform, characterized in that, in a method for depositing glass soot by spraying a glass composition liquid raw material made into a mist with hydrogen-containing gas from a nozzle, mixing with an oxidizing gas, combusting, and blowing the flame to a target, a direct-current voltage is applied between the nozzle and target (negative voltage to nozzle side, target grounded), resulting in ionization of the gas from the

nozzle to charge the glass soot with static electricity with efficient adsorption of glass soot to the target.

Detailed explanation of the invention

Previously, we had proposed a method for depositing glass block for optical fiber by glass composition liquid raw material made into a mist by a hydrogen-containing gas, mixing with oxidizing gas, combusting, and blowing the flame onto a target (Japanese Kokai Patent Application No. Sho 54[1979]-715). This method produces glass block at high speed and high yield and is advantageous in continuous production.

In the above method, the present invention is to provide a method for depositing glass block in higher yields. Namely, by applying a high direct-current voltage between the nozzle and target (negative voltage to nozzle side, target grounded), the gas from the nozzle is ionized, resulting in charging of the glass soot with static electricity and adsorption of glass soot to the target with good efficiency. With ionization of the gas from the nozzle, while passing through the nozzle, static electricity-charged, negatively charged glass soot is attracted to the target grounded in the opposite polarity. The glass soot deposited on the target is heated with flame on the target surface, thus the electric resistance of the glass soot is reduced, and the deposited charge escapes to the target, and static electricity acts further on the blown glass soot. As a result, glass soot is built up efficiently on the target. And, glass soot is deposited in uniform thickness on the target. Furthermore, glass with different refractive index and composition can be deposited uniformly.

Figure 1 shows a schematic diagram of a method for making glass block of the present invention. By feeding a hydrogen-containing gas into a pipe (3) in the arrow (4) direction, the glass composition liquid raw material (1) is sucked up through the pipe (5) in the arrow (6) direction, and the liquid from the nozzle (5') is converted into a mist (16) by the gas from the nozzle (3'). The mist liquid (16) is sprayed through the nozzle (11') of the pipe (11) and ignited at the nozzle outlet to produce a flame containing glass soot. An inert gas (Ar, N_2, He, Ne, etc.) is allowed to flow in the arrow direction (8) in the pipe (7), while an oxidizing gas is fed from the arrow direction (10) in the pipe (9), and in front of the triple pipe nozzle, the hydrogen and oxygen are burnt to generate a high-temperature glass soot-containing flame with deposition of glass soot (15) on the target (12). When the growth of glass soot is speeded up (growth speed > 100 g/h), about 50-60% of the glass soot does not adhere to the target and scattering occurs. To prevent such scattering of glass soot, a high-voltage direct current (21) is applied between the triple pipe nozzle and target, with the nozzle side at negative voltage and the target side grounded, resulting in ionization of the gas from the nozzle to give glass soot charged with static electricity and the negatively charged glass soot being attracted to the oppositely charged target. The surface of glass soot deposited on the target is heated with the flame, thus upon deposition of

the negatively charged glass soot on the target, the charge escapes to the target. This phenomenon occurs continuously, and the glass soot deposition continues. By turning the target in the arrow direction (14) and moving in the arrow direction (13), a long glass soot block of large diameter can be obtained. If the flame temperature is raised further, the glass soot deposited on the target is melted forming a glass. The adhesion efficiency of the glass soot on the target increases with increasing the high-voltage direct current (21). Usually, several kV to several hundreds of kV is preferred.

Figure 2 shows an example with further increased deposition efficiency of glass soot on the target. A cylinder (23) is installed around the glass soot-containing flame (16'), and a negative voltage is also applied to the cylinder with further charging of static electricity to the glass soot. In this case, a thermal insulator (e.g., ceramic fiber wool, glass wool, alumina, etc.) is placed on the inner wall of the cylinder (23). Besides increasing the deposition efficiency of glass soot, this cylinder also prevents flame fluctuation and target surface temperature fluctuation.

An example with or without application of dc voltage (21) in the device of Figure 1 is described. A H_2-Ar mixed gas (H_2 = 3 L/min, Ar = 5 L/min) is fed from the arrow (4) direction, and the liquid (1) ($Si(OC_2H_5)_4$) in the container (2) is sucked up in the arrow direction (6) and sprayed from the nozzle (11'). N_2 gas is fed from the arrow direction (8) at a rate of 2 L/min, and the spray liquid is combusted by ignition at the nozzle outlet. Then, O_2 gas is fed from the arrow direction (10) at a rate of 2.5 L/min, generating the glass soot-containing flame (16') in front of the nozzle. As a result, glass soot is deposited on a target (12) (a quartz glass container of diameter 76 mmϕ with its back side lined with a metal plate: the metal plate is not shown) placed about 20 cm forward from the tip of the nozzle. In this case, the target is turned in the arrow direction (14) at a rate of 20 rpm and lifted in the arrow direction (13) at a rate of 15 mm/h. The amount of the liquid mist sprayed from the nozzle (11') is about 650 g/h. As a result, the deposition rate of the SiO_2 glass soot on the target is about 73 g/h, with a deposition efficiency of about 40% which is low. Next, 18 kV of dc voltage is applied to (21) in a similar experiment, giving a deposition rate of about 125 g/h and a deposition efficiency of about 69%, which is an improvement. In this experiment, the burner is made from a metal container.

As shown above, by applying a dc voltage between the nozzle and target, the deposition efficiency of the glass soot on the target can be increased.

As shown above, according to the method of the present invention, a glass block can be deposited at high speed in high yields and also can be produced continuously, which is an advantage. However, with continuous feeding of the liquid described above, it is difficult to press the liquid surface, making long-term deposition of glass block at high speed difficult.

Here, we have contemplated a method for solving such problems. Namely, by providing a method satisfying both the method for continuous feeding of glass composition liquid raw

material into a container and the method for pressing the liquid surface, glass block can be deposited at a high rate for a long period of time. Next, this method is explained with an example. This method can be applied to the method of the present invention described above and also the method before the present invention with no voltage applied between nozzle and target.

Figure 3 is a schematic diagram to explain the method for the manufacture of glass block for optical fibers of the present invention. A hydrogen-containing gas is fed into the gas inlet pipe (103) from the arrow direction (104) and sprayed from the nozzle (103'), sucking up the glass composition liquid raw material (101) in the container (102) through the pipe (105) in the arrow direction (106), and the liquid from (105') is atomized by the above gas and sprayed as a mist (116). This mist is sprayed together with the gas from the nozzle (111'), mixed at the nozzle outlet with an oxidizing gas fed in the arrow direction (110) and ignited to generate a flame. As a result, the liquid mist undergoes an oxidation reaction, giving a glass soot-containing flame, and this flame (116') is blown to the target rotating in the radial direction (shown by arrow (114)) and moving in the axial direction as shown by the arrow (113), for deposition of glass soot (115) on the target. The gas fed from the arrow direction (108) is an inert gas for mixing oxygen and hydrogen in an area away from the nozzle outlet to the axial direction. A pressing device (117) exerts a pressure on the surface of the liquid (101) inside the container (102), and this pressure controls the amount of liquid sprayed from the nozzle (105'). The container (102') acts as a storage container for recycling the liquid that is dropped by colliding to the inner wall of the protective pipe (111) without being sprayed through the nozzle (111') and flows down in the arrow direction (120), for spraying, and also plays a role of feeding liquid for spray into the container (102') through the pipe (119) from the liquid feeder (118). The liquid (101') in the container (102') is fed into the container (102) through the fine pipe (121). With the pipe (119) of inner diameter smaller than or comparable to that of the pipe (105), most of the pressure exerted to the surface of the liquid (101) by the pressure device (117) is used for pushing up the liquid (101) in the arrow direction (106) inside the pipe (105), to increase the amount of liquid spray from the nozzle (105'). Some pressure added to the inner diameter of the pipe (121) results in the height difference h between the liquid levels of the liquid (101') and the liquid (101). Thus, in this method, the pressure added from the pressure device (117) is capable of bringing the liquid surface of the liquid (101') to a desired position in the nozzle (103'), thus with a constant flow rate of gas fed from the arrow direction (104), the amount of liquid sprayed from the nozzle (111') can be controlled over a wide range. A specific example is illustrated in Figure 4. This is an example of measurement of the amount of liquid mist sprayed from the nozzle (111') when $Si(OC_2H_5)_4$ is used for the liquid (101, 101'), H_2 gas for misting the liquid from the arrow direction (104) is fed, and for the pressure device (117), the gas from N_2 gas bomb is used through a flow meter blow pipe (allowing partial gas leak) to add gas pressure inside the container

(102). As shown in this figure, by increasing pressure gas flow rate (flowmeter reading), the liquid mist amount can be effectively controlled. Figure 5 shows relationship between the glass soot deposition rate and the pressure gas flow rate in using the device of Figure 3. This is a result from H_2 gas flow 10 L/min from the arrow direction (104), N_2 2 L/min form the arrow direction (108) and O_2 5 L/min from the arrow direction (110), using $Si(OC_2H_5)_4$ for the liquid (101, 101') and quartz glass pipe (with sealed bottom) of outer diameter 44 mmϕ for the target. As clearly shown from the figure, the glass soot deposition rate can be controlled by the pressure gas flow rate. More specifically, (118) may use a device for continuous or intermittent feeding of liquid by a liquid metering pump into the container (102') or a liquid feeder fitted with a valve for control of liquid flow in.

This method is not limited to the examples given above. For example, the liquid filled container (102') may be more than one connected in series. The fine pipe (121) connecting the containers (102, 102') may be fitted with a filter for prevention of impurity flow in. The container (102') may be placed higher than the container (102) for enhanced pressuring effect. The container (102') with larger volume than the container (102) is more effective for adding pressure. The gas fed from the arrow direction (104) may be H_2 or H_2 gas mixed with at least one inert gas such as N_2, Ar, He, Ne, etc. The type of liquid, type of gas, target structure, nozzle shape and material, etc. in the present invention are similar to those in our previous patent application (Japanese Kokai Patent Application No. Sho 54[1979]-715).

The method for rapid, sustained deposition of glass preform for optical fiber described above can be summarized: A method for the manufacture of glass preform for optical fiber, characterized by including a method for continuous feeding of liquid and a method for controlling glass block deposition speed by pressuring the liquid surface, in a method for depositing glass block for optical fiber by spraying a glass composition liquid raw material made into a mist with hydrogen-containing gas from a nozzle, mixing with an oxidizing gas, combusting, and blowing the flame to a target.

Brief description of the figures

Figure 1 is a schematic cross section diagram of a device used in the first example of the present invention. Figure 2 is a schematic cross section diagram of a device used in another example of the present invention. Figure 3 is a schematic cross section diagram of a device for making optical fiber preform with an improved feeding method of glass composition liquid raw material. Figure 4 is a graph showing the relationship between H_2 gas flow rate and liquid spray amount in using the device illustrated in Figure 3. Figure 5 is a graph illustrating the relationship between pressure gas flow rate and glass soot deposition speed in using the device shown in Figure 3.

In each figure,

1 glass composition liquid raw material
4 hydrogen-containing gas input direction
6 direction of the glass composition liquid raw material sucked up
8 inert gas input direction
10 oxidizing gas input direction
12 target
21 dc high voltage source
101 gas composition liquid raw material
104 hydrogen-containing gas input direction
106 direction of glass composition liquid raw material sucked up
108 inert gas input direction
110 oxidizing gas input direction
112 target
115 glass soot
117 pressuring device against the surface of glass composition liquid raw material
118 liquid feeder.

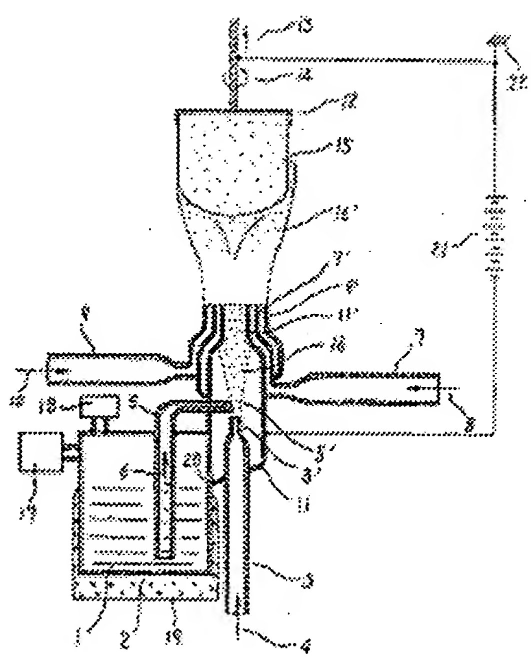

Figure 1

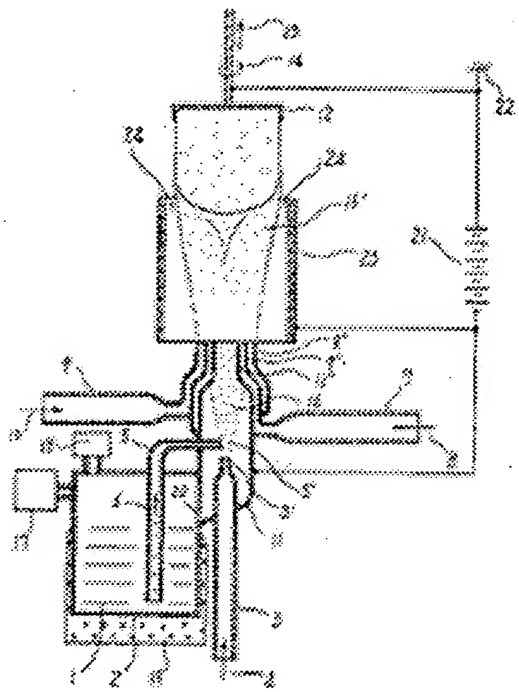

Figure 2

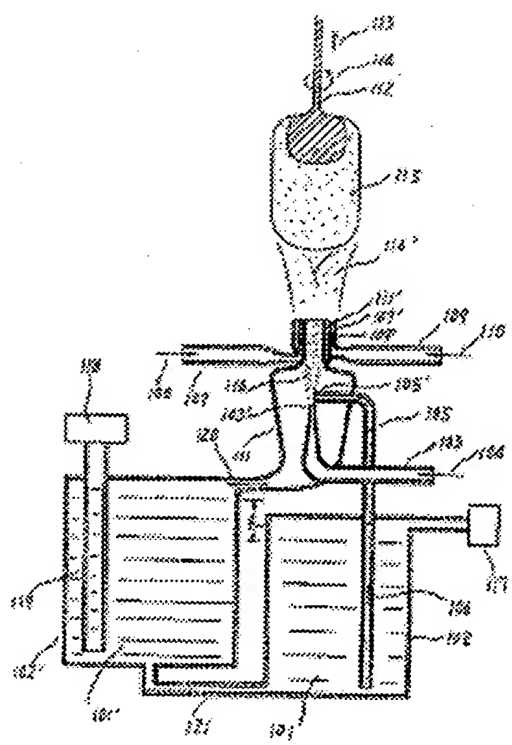

Figure 3

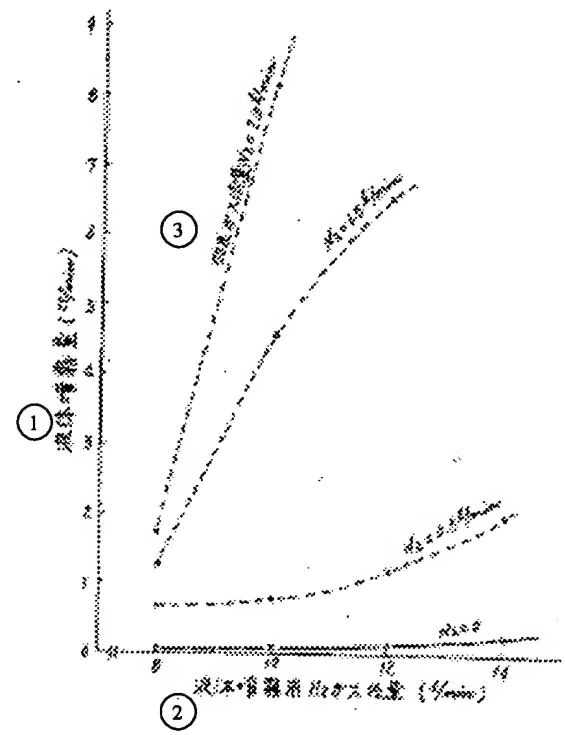

Figure 4

Key: 1 Liquid mist amount
2 H_2 gas flow rate for misting liquid
3 Pressuring gas flow rate

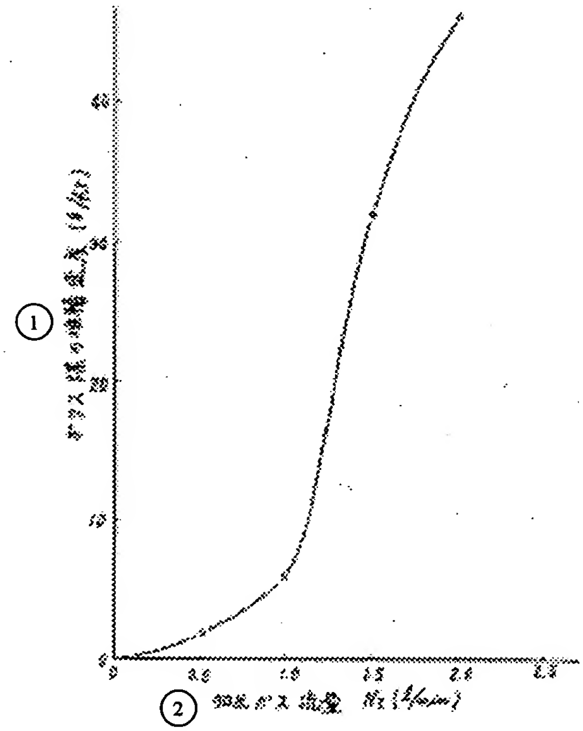

Figure 5

Key: 1 Glass soot deposition speed
2 Pressuring gas flow rate